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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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☐ *Additional inventors are being named on the* _______ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

SWITCHABLE VIEWFINDER DISPLAY

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ Specification *Number of Pages* 6 ☐ CD(s), Number

☑ Drawing(s) *Number of Sheets* 2 ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

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Respectfully submitted,

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Provisional Patent Application

May 8, 2003

Inventors: Milan Popovich, John Gunther, Eric Hansotte

SWITCHABLE VIEWFINDER DISPLAY

Background

This invention disclosure relates to an apparatus for viewing an image. In particular, the invention provides a device for projecting symbology into an optical viewfinder.

There is a requirement for viewing devices that minimize size and weight while satisfying stringent visual optical requirements for high contrast, high resolution and freedom from glare, scatter, or any other impairment of the external scene onto which the symbolic data is superimposed. It is an objective of the apparatus described in the present disclosure to provide a compact high quality and lightweight device for projecting symbology into the field of view of a viewfinder.

It is well known that diffractive optics are ideally suited to projection of symbology. Bragg gratings (also commonly termed volume phase grating or holograms), which offer the highest diffraction efficiencies, have been widely used in devices such as Head Up Displays. An important class of diffractive optical element known as an Electrically Switchable Bragg Gratings (ESBG) is based on recording Bragg gratings into a polymer dispersed liquid crystal (PDLC) mixture. Typically, ESBG devices are fabricated by first placing a thin film of a mixture of photopolymerisable monomers and liquid crystal material between parallel glass plates. One or both glass plates support electrodes, typically transparent indium tin oxide films, for applying an electric field across the PDLC layer. A Bragg grating is then recorded by illuminating the liquid material with two mutually coherent laser beams, which interfere to form the desired grating structure. During the recording process, the monomers polymerize and the PDLC mixture undergoes a phase separation, creating regions densely populated by liquid crystal micro-droplets, interspersed with regions of clear polymer. The alternating liquid crystal-rich and liquid crystal-depleted regions form the fringe planes of the grating. The resulting Bragg grating can exhibit very high diffraction efficiency, which may be controlled by the magnitude of the electric field applied across the PDLC layer. In the absence of an applied electric field the ESBG remains in its diffracting state. When an

electric field is applied to the hologram via the electrodes, the natural orientation of the LC droplets is changed thus reducing the refractive index modulation of the fringes and causing the hologram diffraction efficiency to drop to very low levels. The diffraction efficiency of the device can be adjusted, by means of the applied voltage, over a continuous range from essentially zero to near 100%.

U. S. Patent 5,942,157 by Sutherland et al. and U. S Patent 5,751,452 by Tanaka et al. describe monomer and liquid crystal material combinations suitable for fabricating ESBG devices. A recent publication by Butler et al. ("Diffractive properties of highly birefringent volume gratings: investigation", Journal of the Optical Society of America B, Volume 19 No. 2, February 2002) describes analytical methods useful to design ESBG devices and provides numerous references to prior publications describing the fabrication and application of ESBG devices.

The diffractive properties of ESBG devices can vary substantially with the application of an electric field. The ESBG normally diffracts with high efficiency with no applied electric field, and has much reduced efficiency when an electric field is applied.

Drawings

FIG. 1 is a schematic unfolded view of a Single Lens Reflex (SLR) camera;
FIG. 2 is a schematic side view of the symbol generator;
FIG. 3 is a chart illustrating the diffraction efficiency versus incident angle of an ESBG in the OFF state;
FIG. 4 is a schematic of the exposure system to create the hologram;

Description

The invention will now be further described by way of example only with reference to the accompanying drawings. FIG. 1 shows a schematic unfolded side view of a Single Lens Reflex camera comprising an objective lens 1 which forms a focused image of an external scene on a diffusing screen 4, a symbol generator 3 which projects images of symbols onto said screen, a Light Emitting Diode (LED) 2 optically coupled to the symbol generator and an eyepiece lens 5 through which an image of the scene can be viewed. The symbol generator 3 comprises a light guide and a panel containing a set of ESBG elements as shown in more detail in FIG. 2. The symbol generator is transparent

to external light represented by the rays S. The path of the light from the symbol generator is generally represented by the rays R. By placing the screen at the focal point of the eyepiece an image of the external scene with superimposed symbolic data is formed at some nominal comfortable viewing distance.

Turning now to FIG.2 in which the symbol generator 3 is again illustrated in a schematic side view, it will be seen that the symbol generator comprises a light source 2, a lightguide 15, a beam stop 14, a pair of transparent substrates 10 and 11, and an ESBG region comprising a grating region 12 and flood cured regions 13 on either side of the ESBG grating region. A set of transparent electrodes (not shown) is applied to both inner surfaces of the substrate. The electric field applied will be perpendicular to the substrate. Typically, the planar electrode configuration requires low voltages, in the range of 2 to 4 volts per μm. The electrodes would typically be fabricated from Indium Tin Oxide (ITO). The ESBG region contains at least one grating element 12. Light from the external scene, generally indicated as S in Figure 1, propagates through the symbol generator onto the screen where it forms a focused image of the external scene. The function of the symbol generator may be understood by considering the rays R1 and R2 emanating from the light source 2 and guided initially by the lightguide 15. The ray R2 which impinges on the grating region 12 is diffracted out of the symbol generator towards the screen where an image of the symbol holographically encoded in the ESBG is formed. On the other hand, the rays R1 which do not impinge on the grating region 12 will hit the substrate-air interface at the critical angle and are totally internally reflected and eventually collected at the beam stop 14 and out of the path of the incoming light S.

The grating region 12 of the ESBG contains slanted fringes resulting from alternating liquid crystal rich regions and polymer rich (ie liquid crystal depleted) regions. In the OFF state with no electric field applied, the extraordinary axis of the liquid crystals generally aligns normal to the fringes. The grating thus exhibits high refractive index modulation and high diffraction efficiency for P-polarized light. The diffraction efficiency for S-polarized light is generally lower since the refractive index modulation is lower for that polarization. However, the diffraction efficiency for S-polarized light can be enhanced by modifying the alignment of the liquid crystal and hence increasing the refractive index modulation. This can be accomplished in a number of ways including introducing a chiral dopant to induce cholesteric liquid crystal phases, using alignment

layers oriented at various angles with respect to the grating fringes, or by using electric fields to pre-align the liquid crystals during exposure. By increasing the diffraction efficiency for S-polarized light, higher light throughput can be achieved.

FIG. 3 illustrates the diffraction efficiency versus angle of an ESBG grating in the OFF state. This particular grating has been optimized to diffract red light incident at around 72 degrees (the Bragg angle) with respect to the normal of the substrate. [The scale is missing from the Figure.] The Bragg angle is a function of the slant of the grating fringes and is chosen such that the diffracted light exits close to normal (0 degrees) to the substrate 11 in order to be captured by the eyepiece 5. To maximize the light throughput from the light source 2 to the eyepiece 5, the light source and lightguide should be configured such that light is launched into the lightguide at the Bragg angle This can be accomplished by various means including the use of lenses. Light launched into the lightguide must be at an angle greater than the angle for Total Internal Reflection (TIR) in order to be guided by the lightguide. Hence, the Bragg angle must be chosen larger than the angle for TIR.

When an electric field is applied, the grating switches to the ON state wherein the extraordinary axes of the liquid crystal molecules align parallel to the applied field and hence perpendicular to the substrate. Note that the electric field due to the planar electrodes is perpendicular to the substrate. Hence in the ON state the grating exhibits lower refractive index modulation and lower diffraction efficiency for both S- and P-polarized light. Thus the grating region 12 no longer diffracts light into the eyepiece and hence no symbol is displayed.

In order to ensure high transparency to external light, high contrast of symbology (ie high diffraction efficiency) and very low haze due to scatter the following material characteristics are desirable.

a) A low index modulation residual grating with a modulation not greater than 0.007. This will require a good match between the refractive index of the polymer region and the ordinary index of the liquid crystal.
b) High index modulation capability with a refractive index modulation not less than 0.06
c) Very low haze for cell thicknesses in the range 2-6 micron

d) A good index match (to within ±0.015) for glass or plastic at 630 nm. One option is 1.515 (for example,1737F or BK7 glasses). An alternative option would be 1.472 (for example Borofloat or 7740 Pyrex glasses)

FIG. 4 is a schematic drawing of a laser exposure system to create the ESBG grating in the symbol generator. It consists of a prism 20 placed on top of the substrate, a mask 21 to define the shapes of the symbols to be projected, and two mutually coherent laser beams B1 and B2. The mask defines an aperture through which a portion of the beam B1 can impinge on the mixture of photopolymerisable monomers and liquid crystal material between parallel substrates 10 and 11. This portion of the beam interferes with the beam B2 creating a grating region 12 which consists of alternating liquid crystal rich and polymer rich regions. The shape of the aperture defines the shape of the symbol. A plurality of symbols can be created in this way. Each symbol can be independently controlled by an independent pair of planar electrodes. The planar electrode should be aligned with the symbol in order to effectively realign the liquid crystal molecules with electric fields. Typically, the electrode on one substrate surface is uniform and the electrode on the other surface is patterned to encompass the plurality of symbols.

The flood cured region 13 is created by the single beam B2. Since there is no intensity variation in this region, no phase separation occurs and the region is homogeneous, haze-free and generally does not respond to applied electric fields. Since this region does not generally respond to the applied electric field, the patterned electrodes do not have to be perfectly aligned with the symbol created by the aperture in the mask. The patterned electrodes must at least encompass the symbol, but can be larger in order to relax alignment tolerances.

In one practical embodiment directed at SLR cameras the symbol generator would have an aperture of 30 mm square. The beam inside the light guide would have an incidence angle of 72 degrees corresponding to the Bragg angle of the ESBG grating.

The symbol generator could be configured to provide symbols of different colors by providing ESBGs optimized for the required wavelengths and LEDs of appropriate spectral output.

In a further embodiment of the basic invention the several ESBG panels could be stacked such that by selectively switching different layers it is possible to present a range of different symbols at any specified point in the field of view.

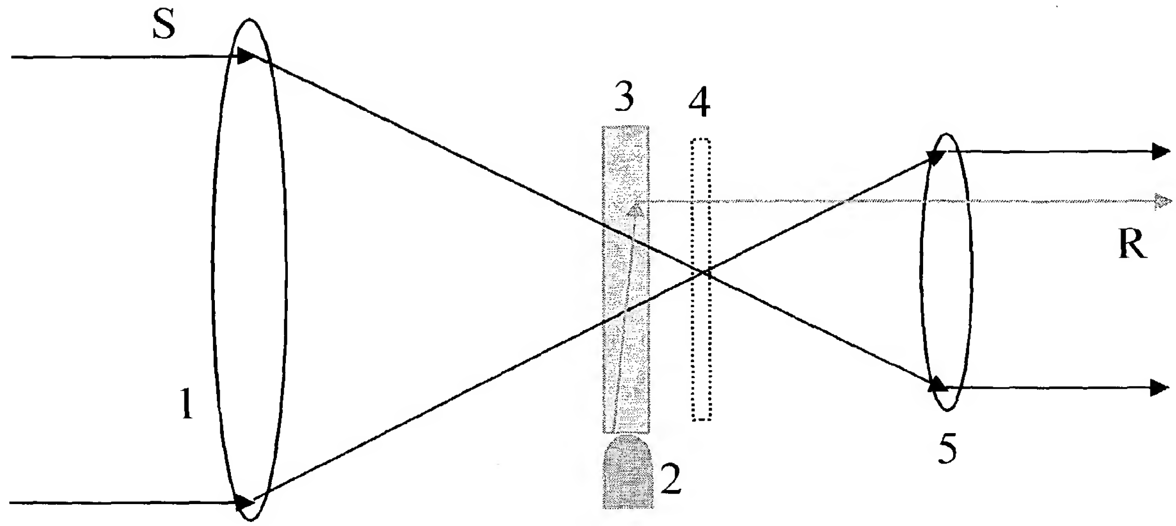

Figure 1.

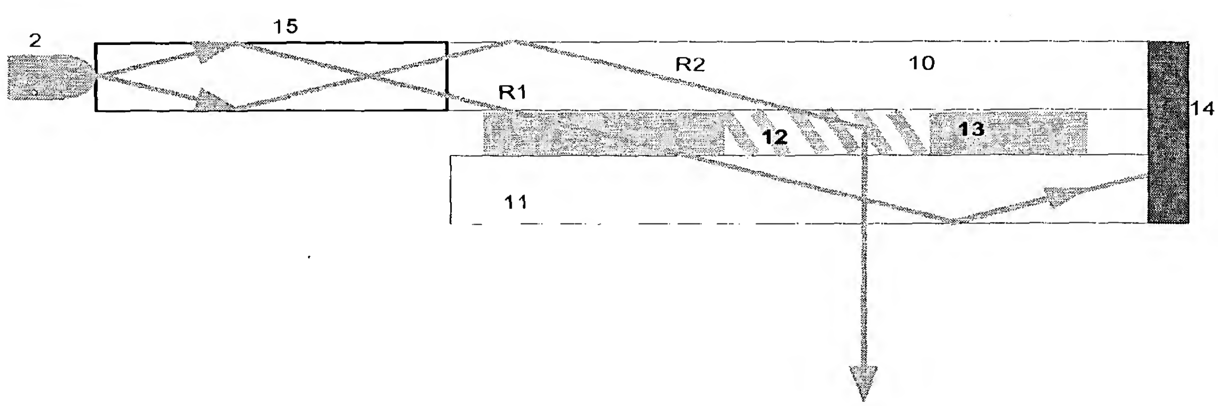

Figure 2.

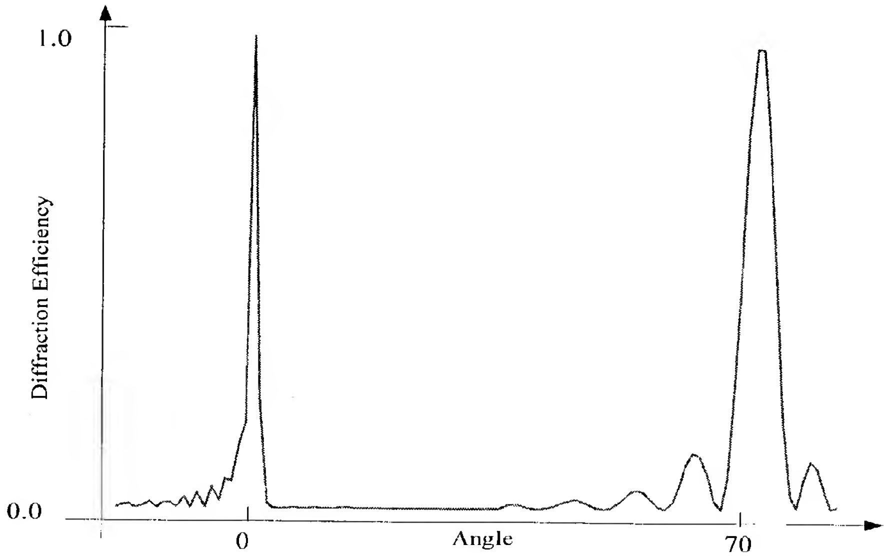

Figure 3.

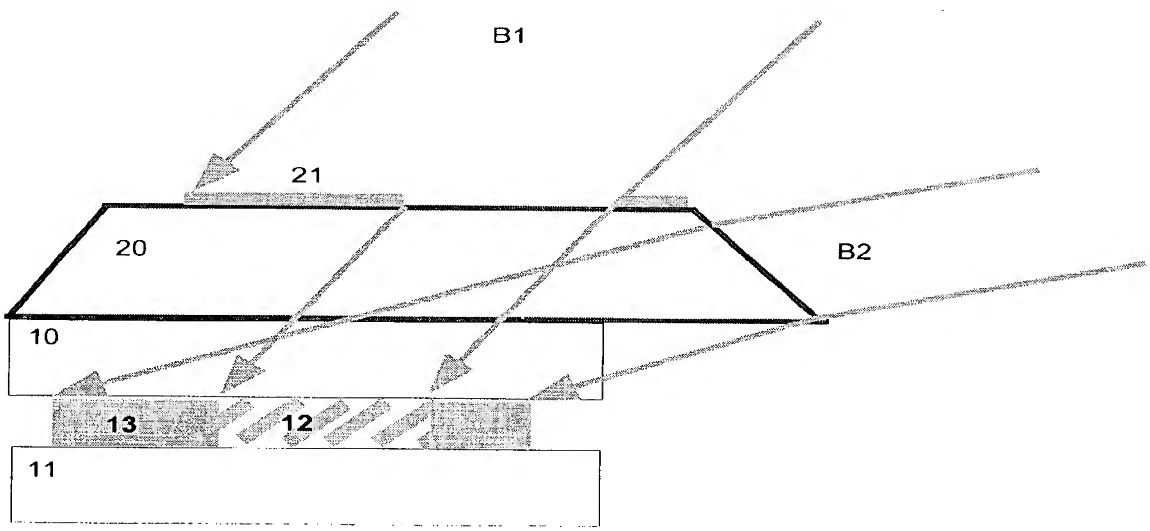

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Figure 4.